Design and Development of Product Sorting Robot

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Abstract—**The EV3 Product Sorting Machine is designed and implemented to provide a better machine for industry that will act on behalf of the workers in an industry; by helping to sort the products according to the type without the usage of manpower. This machine will detect when the stock arrives from the factory, then sort it and arrange it in their categories. It will record the total number of available stocks in the store and it also can withdraw stock from storage by their categories. The main idea of this proposal is to solve certain problems in the industry such as manufacturing industry that needs a lot of manpower to complete their work. But they have potential to make mistaken or errors while sorting the products accordingly and they also have difficulty to calculate the available stocks. The objective of this research is to create a sustainable robot that can sort products according to the code, to classify products according to its category and to identify the number of available products from each category. Here, the image processing method is implemented to determine and read the code on the label of the product; once the image of the code is processed it will instruct the next execution. Developing this robot project is more significant as this invention could help the industry to be more systematic with advantage of lesser human errors and is cost saving as less manpower needed.**

Keywords—EV3 robot; product sorting; image processing;

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I. INTRODUCTION

ROBOTS are machines that capable of doing what they are programmed to do. This machine has shown its significance by decreasing the human workloads; especially in industry. In manufacturing industry, the tasks, speed and efficiency have been improved upon by robotic systems. Robots have replaced humans in many industries, especially in repeated or dangerous situations. A line follower robot is generally a robot that tracks and follows a pre-defined black line or path on a white surface [1]. The importance of the robotics in the field has been acknowledged by researchers since the first machine development began. The reason is to provides a useful tool for environment detection and decision-making during automation processes. The drawbacks of robotic operations are three; firstly, is the needed to include extra hours operational activities for this program and they are limited to certain predefined operations that cause rigid the automation. One solution to improve system adaptability is to integrate image processing and make it open to other potential applications. For example, work by [2] aimed to imitate human behaviour in sketching human facial portraits. There are 10 types of new robotic trends, which are bio inspired robots, micro-nano-femtorobots, walking machines, toy robots, ubiquitous robots, household robots, cloud robots, flying robots, autonomous driving vehicles and modular self-reconfiguring robots.

At this age of technology, the flow of goods transaction will play an important role in human daily lives. The customers buy things from a merchant, and the merchant gets his stock from a factory. This circular flow of economic

activity will show the balance of revenue and the outcome of our country. Therefore, any element or party within this cycle is undeniably important, any party failure within this cycle will have a major or serious effect on the economic balance.

Cloud robots are said to be an exciting possibilities in the near future because of their minimised requirements for on-board processing, which can increase efficiency in performing complex tasks [3]. A Google researcher claimed that cloud computing could make robots smaller, cheaper, and smarter. The call of this approach as 'cloud robotics,' will allows the robot to offload computer-intensive tasks, like image processing. Cloud robotics will make the idea of expanding the robot's knowledge beyond its physical body is possible [4].

Representational State Transfer (REST) is designed to bring dominance advantages of current protocols. REST can be used for nearly all existing protocols. It helps developers without installing libraries or additional software. REST data doesn't depend on any techniques or resources and has the ability to handle various types of calls, to return different data formats and to alter structures with proper hypermedia implementation. There are two 'Clouds' that claim to use the REST concept, namely Google Cloud API and SightHound. These Clouds allow developers to understand computer visions in image content by enabling a powerful machine learning model to classify images, detect objects and read printed words contained within images. These Cloud API were used in [5]–[8]. Comparison for these two cloud had been done in [9], [10] in robot prototype for thrash collecting.

From the business interest, if this robot is implemented in real life, it will bring many benefits to mankind. This process is helping to build a prototype robot that satisfies the 9th goal of the UN-sponsored sustainable development goals–' Industries, Innovation and Infrastructure.' Many business approaches can be implemented, as there are many important distinctions to be drawn in this goal, which is relevant to the development of a successful project.

The problem statements stated below are to be overcome by developing a robot, the manufacturing industry needs a lot of manpower to complete its work. Manpower is most needed in this sorting sector of work in order to sort work achievement. This is because attention is required for the sorting process, as the categories of products may be the same. Workers always make mistakes or errors in sorting the product to the right place.

Human error has a major impact on this work, and it cannot be resolved in a short period as it could affect the productivity of a company. Human error often occurs as workers are distracted by physical constraints such as fatigue and health problems. In addition, many errors also occur in stock details because there are many filing processes involved, such as storing incoming and outgoing stock data. It is difficult to calculate the amount of stock available on the rack. Using this manual sorting method, it is difficult for the person in charge to retrieve the amount of stock available in the rack. It is because the duty managers differ every week as they take turns in monitoring the stock, which is very difficult to keep track of the stock. This manual sorting method is not effective because the number of stocks available in the rack is not updated systematically.

This paper proposes that EV3 Product Sorting Robot will help a great deal by filling the gap between the merchant and the manufacturer and the customer. This robot will detect the stock coming from the factory, sort it and sort it into its categories. At the same time, the total number of stocks available in the warehouse will also be recorded. This will save a lot of man's power and prevent human error by sorting and calculating the stock.

The main objective of this project is to implement a better solution that will act on behalf of workers in the industry by helping to sort products by type without the use of human power. Our project is more important in developing this robot, as this invention could help the industry to work more systematically with fewer human errors. Also, this project will also make it possible for the industry to save a lot of money as less manpower is needed to work.

II. EV3 PRODUCT SORTING ROBOT

Product sorting robots are rarely seen today. This project is a new attempt to bring more advanced innovation to the society. Product sorting has always been done manually all this time. In large companies, their products are manually sorted by workers in which consume a lot of manpower and time. Product sorting is done manually because it is a very technical matter and needs a lot of attention to sort products by type. A solution is needed to reduce the amount of manpower used and to improve the sorting process by reducing the duration of product sorting by using a robot. The EV3 Product Sorting Machine is therefore designed to overcome the face problem.

Many aspects need to be addressed before the robot is developed. But with everything sorted to perfection, the robots will flow smoothly. First, the product on the track is detected from a certain distance using an ultrasonic sensor, then the webcam set at the top of the track captures the product label and reads the code on the label for further sorting. Then the product will be moved forward so that it can be transported to the rack. Overall process flow for EV3 Product Sorting Robot shown in Fig. 1.

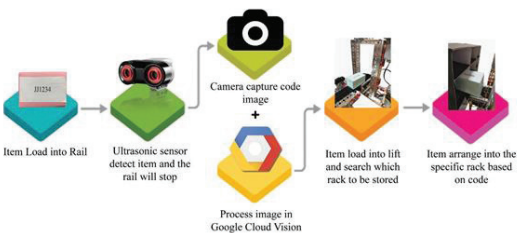

Fig. 1. Process flow for EV3 Product Sorting Robot

Here are the details about the EV3 product sorting robot that has been developed.

A. System Scope

The module has been divided into three modules.

- Movement Module

In this module, the robot's movement will be controlled to move the products and place them in the correct space in the rack.

- Sensors (Detection and Response) Module

This module is designed to detect the presence of the product on the track so that it can be sorted correctly.

- Intelligent Module

This module is specially developed to help detect the type of product on the label using an image-processing technique.

V-Model will be used as project development in this project (see Fig. 2). V-Model is a representation of the life cycle of the system development (SDLC). It is also known as the Model of Verification and Validation. The V-of the model is a sequential process execution path. In this method, each process indicates that each phase should be completed before moving to the next phase. This methodology is very well suited to the development of our project because it is convenient to develop this system step by step without skipping any processes. Testing activities, such as planning or design, are carried out before the coding phase begins, which gives a higher chance of completing this project. Furthermore, by using this model, it can track any defect at an early stage, which helps to save our time by not getting the wrong path.

B. Robot Development Methodology

There were three phases involved in the development, which are:

- Verification Phases

Coding phase will play the role to join both the sides of the phase to form V-Model Verification Phase. The stages of verification in V-Model are as follows:

-At Requirement analysis stage, all possible requirements for the development of this EV3 Product Sorting Machine are captured and documented in a specific document. Here, the required information is collected and analyzed to identify the problem statement of the current system and to determine the objective to be achieved by the proposed system.

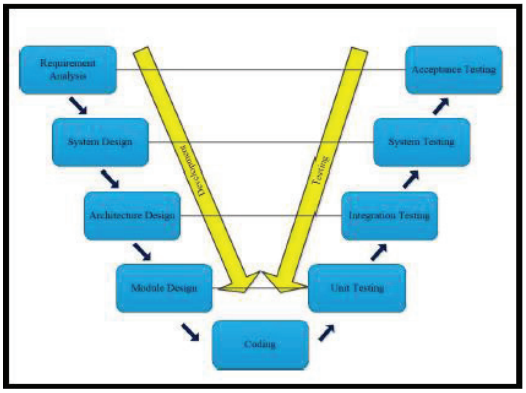

Fig. 2. V-Model architecture for EV3 product sorting robot

- The system design must be analyzed and understood in overall. First, the robot system must detect the presence of the product where the input track is using an ultrasonic sensor. Then the webcam on the track will reads the product label code to identify the product code. Once the label has been detected, the product will be sent to the rack again, depends on the type of product.

-In architecture design, the robot track has been moved by the EV3 Large Servo. The product on the track is detected from a distance by an ultrasonic sensor, then the webcam, which has been set at the top of the track, captures the product label and reads the code on the label for further sorting. Then the product will be moved forward so that it can be transported to the rack.

- Coding Phase

This is a major part of the project and a thorough discussion of the round table is needed before implementation. After the coding phase, we tested our robot to make sure it was fully functional and working well in the set environment during the task. To build a reliable robot, Python will be used as the primary programming language along with the custom ev3dev firmware. The Google Cloud Vision API library is used for image processing. Besides, the pre-ev3dev library is used to access EV3 engines and sensors.

- Validation Phase

Several tests will be carried out during the validation phase. Testing is as follows:

-Unit testing is carried out during the design phase of the module. These testing processes are run to remove bugs at the code level or the unit level. Unit testing verifies that the smallest entity can function correctly when isolated from the rest of the codes, e.g. the functionality of label identification.

- Integration tests are developed during the design phase of the architecture. The combined functionality processes are tested in this test.

-In system testing, the functional and non-functional requirements that have been met are verified. The system is tested many times to ensure that functionality, interdependence, and communication are fully computed.

- User Acceptance Tests are run multiple times to ensure that the system works as planned. Also, this process refers to the internal logical system to ensure that all the coding statements tested are fully functional outside. These tests will be carried out to identify any errors that might arise and to ensure that all inputs interpreted will produce a real achievement and a proper program as planned.

C. Robot Development Technique

There are a few techniques to be implemented in this project to be developed. Data from different sources have been collected and interpreted. The component and mechanisms of the robot's functionality are also being analyzed and discussed. Using IT technology, the image processing method is used to identify and read the code on the product label, and once the code image is processed, the next execution process of the robot to place the product in the rack according to the specified space will be instructed. In addition, tests were carried out to ensure the best position of the rack, depending on the height and distance of the rack, in order to ensure that the products were correctly placed in the rack without any obstacles.

While building a robot body, exploring the Google Cloud Vision API library and recording output from the algorithm has been done as well. The operation of hardware and software is very important because it is an important step forward to make the entire robot work properly. The requirements for robots are divided into two categories. The requirements for software are the first category. The software requirement

may be used to describe the software used to develop the system. Here, two software programs will be used. First, Ev3dev is a Debian Linux-based operating system that runs on several LEGO MINDSTORMS compatible platforms, including LEGO MINDSTORMS EV3. It's not a firmware and will give you the power to program how you want to control the sensor, the engine and everything else using a low-level driver framework. Second, the Visual Studio Code, which is the Python 3.7 source code editor for this project. It can control the ev3 robot by installing the ev3dev extension inside the framework control.

The second category is hardware requirements, while the hardware requirements used to support the robot are hardware requirements (see Table 1). Fig. 3 presents the Structure Chart of EV3 Product Sorting Robot.

III. EXPERIMENTS AND RESULTS

EV3 Product Sorting Machine is a robot programmed to sort products by category. The Intelligent Module, which is integrated into the robot application, enables the robot to make a better decision in sorting the products according to the category by referring to the label on the product. The design is based on a limited number of sources, such as the internet and books. The design of the robot is designed as planned and designed in the early stages.

Table 1 Lists of hardware requirements for support robot program

No.	Hardware	Description
1.	Tetrix Set	• To develop the main frame of the robot architecture.
2.	EV3 Lego Mindstorms Set	• To develop the supporting parts of the robot architecture.
3.	Lego EV3 Brick	• To allow to upload the code into the robot. • To controls all the movement of the robot.
4.	Micro SD Card	• To install the ev3dev firmware in Lego EV3 Brick.
5.	EV3 Large Servo Motor	• To enable the movement function of the processes.
6.	Ultrasonic Sensor	• To detect the presence of product on the track and to stop the track for scanning the label (Image Processing Process).
7.	Webcam	• To help in label recognition of the product, and processes the result to give the output of the respective place in the rack.

The EV3 Product Sorting Robot is designed using the Tetrix Set and the Lego Mindstorms EV3 components, which contain channels, bricks, motors, and sensors. Components are designed primarily using the Tetrix robotic style and this ensures that each component is correctly fixed following the use of the components. All components used to build this robot are well planned and integrated according to the design orders. This EV3 Product Sorting Machine has good functional processes to sort the products without any hindrance to the architecture. The design of the EV3 Product Sorting Robot is as shown in Fig. 4. The design structure of the robot is based on a humanoid design.

The robot was successfully integrated to implement the three main modules. The Intelligent Module is one of the most important modules, as it will soon query the category of the product to be sorted. In addition, the sensor and detection module and the intelligent module will be tested during the testing phase to determine functionality and usability accuracy (see Fig 5-7).

From under three modules, 45 runs are carried out on each module. For the movement module, the movement of the lift to sort the product by type has been tested. The ultrasonic sensor then detects the presence of the product on the track for the sensor (detection and response) module. Finally, on the Intelligent Module, the system has been tested to correctly read the label through the webcam. Fig. 8 showed there is some minor failure as the hardware used does not move exactly according to the code due to the less lift movement accuracy. The code embedded in the ultrasonic sensor works perfectly without any error.

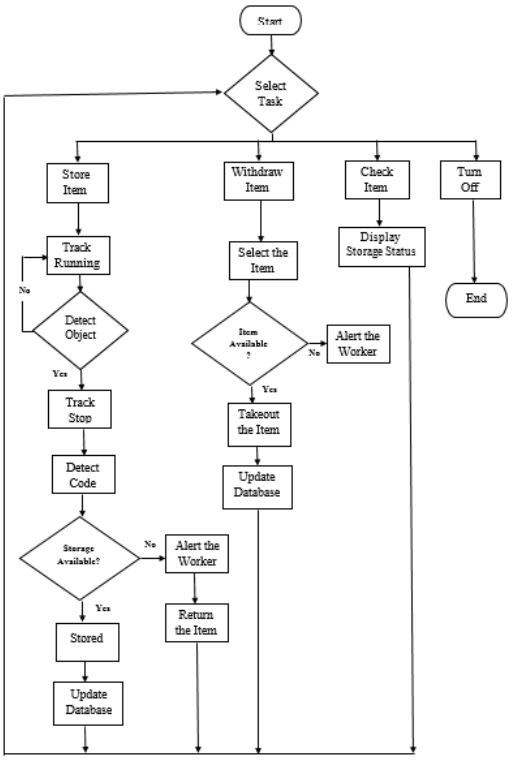

Fig. 3. Structure Chart of EV3 Product Sorting Robot

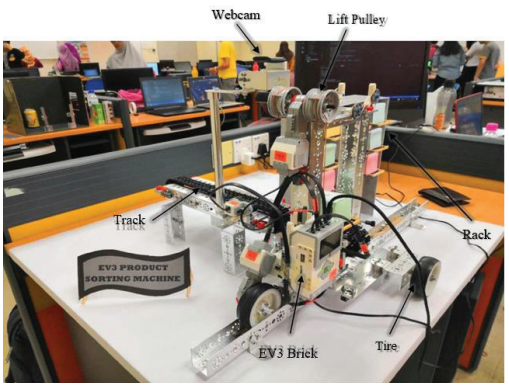

Fig. 4. Final design of EV3 Product Sorting Robot

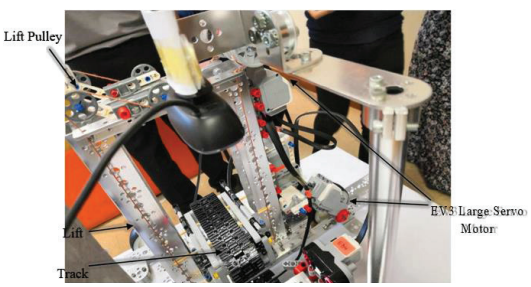

Fig. 5. Movement Module Components

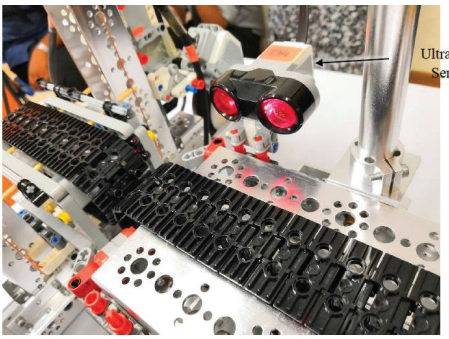

Fig. 6. Sensors (Detection and Response) Module Components

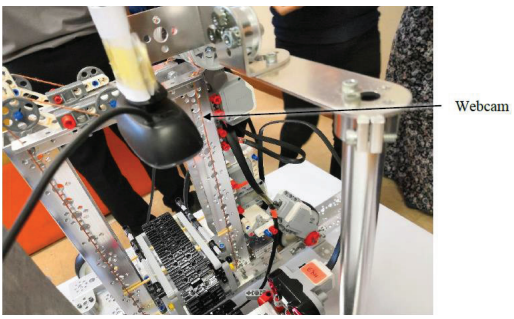

Fig. 7. Intelligent Module Components

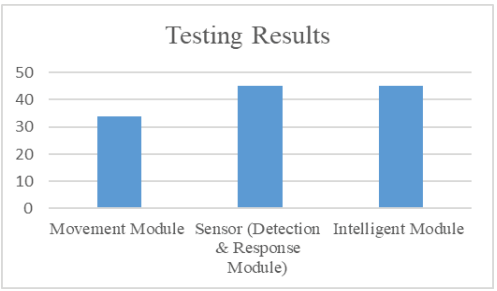

Fig. 8. Test result for each module developed

The label is perfectly detected and read during the image processing process as the webcam level is at the right height and the Google Cloud Vision API library functions well.

IV. CONCLUSION

Today, this robot, the EV3 Product Sorting Robot, would be a very useful invention to solve many main problems in the industry. This robot can help reduce the manpower for the task of sorting process and can indirectly avoid human error. There are so many benefits

of using this robot in industries as this robot can be programmed to operate 24/7 in lights-out situations, rather than in human situations, that the productivity of the company has increased, making businesses more profitable. The human error also can be reduced to almost none by using this EV3 Product Sorting Machine, which is significantly will reduce the company's losses. With these advantages, it could be easy to make the most of the EV3 Product Sorting Machine as a huge attraction to the market.

The EV3 Product Sorting Machine has few small weaknesses that can be easily fixed while preparing the robot for deployment in the real world. Hardware and software constraint are the main weakness. Since the EV3 Product Sorting Robot is a prototype, it was built from the EV3 Lego Set and Tetrix Set, which is unlikely to be used in the real world. Besides, the movement of the lift is sometimes disturbed due to a hardware imperfection, which reduces the accuracy of the lift movement by coding, which disrupts the sorting process to the rack. Therefore, transforming it into a stronger and a better-quality metal material would solve a lot of problems.

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